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RIGHT TO LEFT HEMISPHERIC SHIFT IN OCCIPITAL ELECTROENCEPHALOGRAPHIC RESPONSES TO REPEATED KIMURA FIGURES[1]

M. A. PERSINGER AND CARRIE-ANNE LALONDE

Laurentian University

Summary.—Gordon and Carmon (1976) reported that repeated presentations of an initially novel stimulus were associated with a transfer of cerebral dominance over time (trials) from the right to the left hemisphere. To test the generalizability of these results the proportions of alpha rhythms over the left and right occipital and parietal lobes were measured following the presentation of recurring and nonrecurring complex visual patterns (the Kimura Figures) to the upper or lower, left or right peripheral visual fields. Analysis showed increased electrical activation (as inferred by attenuated proportions of alpha rhythms) of the left occipital lobe but decreased activation of the right occipital lobe. This shift occurred during repeated presentations of the same stimuli but not during single presentations of different novel stimuli. There was no significant shift in this activity over the parietal lobes. These results are consistent with the reports of other researchers who have found a shift of dominant neuroelectrical activity from the right to the left hemisphere as the novelty of a visuospatial stimulus decreases.

The human brain's response to novel stimuli are associated with changes in cerebral activity that have been attributed to shifts between the affective ("right hemispheric") and the categorical ("left hemispheric") domains of neurocognition (Gordon & Carmon, 1976; Kosslyn, Koenig, Barrett, Cave, Tang, & Gabrieli, 1989). If a visuospatial stimulus is novel and has minimal linguistic equivalents, then one would expect vigilance and maximum activation of the visual regions of the right hemisphere. Once this representation has been translated (perhaps even after a single trial) into left hemispheric (linguistic) codes, subsequent presentations of the same stimulus should activate more of the visual processes within the left hemisphere than the homologous functions within the right hemisphere. The present experiment was designed to discern the generalizability of Gordon and Carmon's observation (1976) that (1) new symbols were recognized faster by the right hemisphere during the beginning of the test session, and, (2) this advantage shifted to the left hemisphere by the end of the test session. We exposed normal subjects to very complex figures (drawings) that were difficult to categorize by familiar verbal labels.

[1]Please send reprint requests to Behavioral Neuroscience Laboratory, Department of Psychology, Laurentian University, Ramsey Lake Road, Sudbury, Ontario, Canada P3E 2C6. Thanks to Sandra Tiller for technical assistance.

Method

Subjects

Eight right-handed university men, 21 to 24 years of age, volunteered as subjects. Reinforcement was a 2% bonus mark for the final grade for a first-year psychology course during the year 1993.

Procedure

Each subject was seated comfortably in front of a Gerbrands tachistoscope. Silver-silver electrodes were attached by EC2 cream over O1, O2, P3, and P4 and referenced to the same neutral region (the ear). An 8-channel Beckman instrument was used for recording. Subjects were instructed to fixate or focus their gaze on a small cross that was located in the middle of the tachistoscopic field. This cross appeared before each trial of the experiment. The subjects were also instructed, emphatically, not to allow their gaze to wander around the viewing screen even though the cross would disappear with the presentation of each test slide.

Eight baseline figures from Kimura's Recurring Figures Test (Kimura, 1986) were presented to the upper left, upper right, lower left, or lower right visual quadrants. There were two pictures per quadrant. During the experiment (64 trials) all of the eight familiar pictures were presented four times while another 32 pictures, to which the subjects had not been exposed, were presented only once. The unfamiliar figures were presented as "controls" or references for the amount of change simply to the presentation of stimuli over time. The sequence was arranged before the experiment began so that the familiar and unfamiliar figures were distributed quasirandomly throughout the 64 presentations. All subjects received the same sequence.

The duration of presentation for each picture was 5 sec., and the time between the ending of one trial and the beginning of the next was about 1 sec. (the time required for the Kodak projector to move the tray and insert the next slide). The subject was requested to push one of two keys on a keyboard as quickly as possible to indicate whether figures were familiar or not familiar. Examination of the reaction times indicated that all subjects responded within 5 sec.

For each trial the experimenter marked quickly, with a single line on the strip chart record, the presentation of the stimulus (as cued by the sound of the projector). When the experiment was completed, the continuous occurrence of alpha rhythms for more than 50% of the time during the 2-sec. period after initial presentation of each stimulus was counted visually for each of the four channels: left or right occipital or parietal regions. These measurements were verified by a second rater who was not familiar with the purpose of the experiment (interrater $r = .92$). Alpha rhythms were defined visually by synchronous, high amplitude changes between 8 and 13 Hz. Be-

cause all subjects required at least 2 sec. to respond, contamination from motor movements and cerebral activation associated with these changes were minimal.

The basic experimental design was a three-way analysis of variance with all levels repeated for each lobe (parietal and occipital) separately. The three within-subject levels were familiar ($n=8$, each four times) vs unfamiliar figures ($n=32$), left vs right hemisphere, and block (first two repetitions for the eight familiar figures and the first 16 figures presented only once vs the second two repetitions of the familiar figures and another set of 16 unfamiliar figures).

Support of the hypothesis required a statistically significant interaction between figure type, hemisphere, and block. We predicted that *post hoc* analysis should show a statistically significant decrease in alpha rhythms over the left occipital lobe for the familiar figures between Block 1 and Block 2 (which would imply activation of this hemisphere) and an increase in alpha rhythms over the right hemisphere for familiar figures between Block 1 and Block 2 (implying a decrease in activation for this hemisphere) while this temporal change between the two hemispheres should not be evident for the unfamiliar (novel) figures. Because the effect-size was predicted to be conspicuous only when each person was employed as his own control, the ratio of the alpha time was calculated for each person. This was completed by obtaining the mean of the percentage time of alpha rhythms (for the 2-sec. increments) for all eight measures (familiar, unfamiliar figures; left, right hemispheres; Blocks 1 and 2) and then dividing each of these measures by this mean value.

The three-way analysis of variance was then completed for these measures as well. All analyses used SPSS software on a Vax 4000 computer. Significance was set at $p<.05$. This marginal value was selected because *a priori* calculation had indicated that for eight subjects the effect size would be required to be at least 50% to achieve this level of statistical significance. Such an effect size was considered by us to be large enough to pursue potential mechanisms in subsequent experiments.

Results

The repeated-measures analyses of variance for the percentage of alpha rhythms (the raw data) as well as the ratio of alpha rhythms (each person as his own control) over the left and right occipital lobes and the right parietal lobes indicated the most statistically significant effect was an interaction between the measures for the occipital lobes. The interaction was between the type of figure (familiar vs unfamiliar), hemisphere (left vs right) and block (1 vs 2) for the percentage of alpha time ($F_{1,7}=10.92$, $p<.01$; partial $\eta^2=61\%$) and the ratio of the occurrence of alpha rhythms ($F_{1,7}=13.75$, $p<.01$; partial

$\eta^2 = 66\%$). The means and standard deviations for the percentages of time alpha rhythms occurred during the first 2 sec. after the tachistoscopic presentation of the figures and the ratio of the values for these alpha times with respect to the mean for each subject are shown in Table 1.

TABLE 1

MEANS AND STANDARD DEVIATIONS FOR PROPORTIONS (PERCENTAGES OF TIME) OF ALPHA RHYTHMS DURING 2 SEC. FOLLOWING PRESENTATION OF KIMURA FIGURES AS WELL AS RATIOS OF THESE OCCURRENCES (REFERENCED TO A PERSON'S AVERAGE) FOR OCCIPITAL LOBES AND RATIOS FOR FIRST AND FOURTH QUARTERS OF THESE STIMULI

Block	Variable							
	Familiar Figure				Unfamiliar Figure			
	Left		Right		Left		Right	
	Block 1	Block 2	Block 1	Block 2	Block 1	Block 2	Block 1	Block 2
Percentage of Alpha Rhythms								
M	22	17	16	23	16	25	23	23
SD	16	18	13	15	14	21	19	19
Ratio of Alpha Rhythms								
M	0.92	0.78	0.72	1.20	0.70	1.05	1.06	1.13
SD	0.51	0.63	0.54	0.42	0.52	0.62	0.86	0.65
Ratios for the First and Last Quarters of Trials								
	First	Last	First	Last	First	Last	First	Last
M	0.86	0.40	0.91	1.34	1.00	0.75	1.85	0.90
SD	0.53	0.45	0.75	0.52	0.77	0.60	0.89	0.57

Post hoc analysis was completed for the familiar figures only to discern if the interaction for trial by hemisphere was statistically significant. Although it was not statistically significant for the percentage of alpha time ($F_{1,7} = 3.27$, $p > .05$; η^2 estimate $= 32\%$), it was significant statistically ($F_{1,7} = 9.35$, $p < .05$; $\eta^2 = 57\%$) for the ratio of alpha seconds when referenced to each subject's individual mean. *Post hoc* analysis for the unfamiliar figures separately did not reach statistical significance ($F < 1.50$).

Because the division of the trials into first and second halves of the experiment would be expected to dilute the major strength of any effects between the initial and final trials, the ratios of alpha rhythms were obtained for the first presentation of the eight familiar figures and the last eight familiar figures as well as the first eight and last eight unfamiliar figures. These results also are shown in Table 1. Although there was a statistically significant difference ($F = 5.76$, $p = .05$; η^2 estimate $= 53\%$) between the two (first and last) quarters, the three-way interaction between quarter, hemisphere, and type of figure was also significant statistically ($F_{9,52}$, $p < .02$; $\eta^2 = 66\%$).

The *post hoc* analysis showed the same pattern as that found with the full analysis. Paired t tests verified the increased ratio of alpha time over the right occipital region ($t = 2.71$) but decreased ratio of alpha time over the left

occipital region ($t = 4.36$) between the first and fourth quarters for the familiar figures. For the unfamiliar figures, the only significant change ($t = 4.22$) was the decreased ratio of alpha time over the right hemisphere only between the first and fourth quarters of stimuli.

Discussion

These results supported the hypothesis that, as familiarity of stimuli increased, the electrical activity over the left hemisphere became more active while the electrical activity over the right hemisphere either remained the same or decreased. A shift during repeated presentations of novel stimuli from nonlinguistic vigilance associated with the right hemisphere to the linguistic categorization of the left hemisphere is consistent with the hypothesis that the human brain may not display the same ratios of hemispheric processes when exposed to the same stimulus over time (Gordon & Carmon, 1976; Kosslyn, *et al.*, 1989). Once a verbal label or linguistic category has been associated with an unknown stimulus, it or stimuli with very similar characteristics would evoke relatively greater activity within the left hemisphere.

In the present study this greater activity within the left hemisphere was inferred by the reduction in the raw incidence of alpha rhythms as well as the ratio of these rhythms over the left occipital lobe following the presentation of the same figures. The measurement of the statistically significant effect over the occipital lobes but not over the parietal lobes suggests the change was not general but modality specific. The placement of the O1 and O2 electrodes would have been adjacent to those areas associated with neurogenic responses to visuospatial patterns (Kuriki, Takeuchi, & Hirata, 1998).

Shifts in cerebral dominance by simple repetition of complex visuospatial or affectively dominated stimuli would be associated with increased contributions from left hemispheric processes to the imagery, interpretation, and salience of the conscious experience of these stimuli. The shift would also decrease the potential to discern or to discriminate those specific components of the original stimulus that required or involved right hemispheric activation. Such alteration should affect the accuracy of information obtained or detected during nonwaking states such as dreams (Gordon, Frooman, & Lavie, 1982). It might explain one of the greatest impedances to experimental psi research: the decline effect. It is associated with the marked and precipitous attenuation in accuracy of the same target stimuli as a function of trials (Hansel, 1966; Rao, 1966).

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